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GENERATING "GREEN LIGHT" SIMULATION IN VEHICLES TRAFFIC USING THE GWTOOL SOFTWARE

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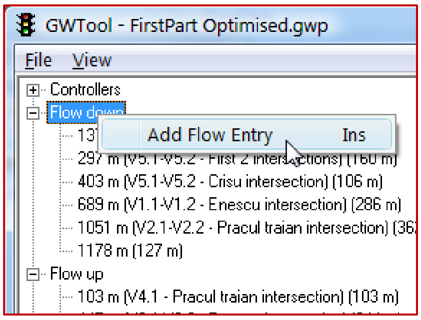
Abstract: Using the simulation GWTOOL program, a PC application that realizes the time distance diagrams for consecutive intersections, we can simulate the "green wave"for an intensively circulated artery that transits the city, in north-west, towards east south. The traffic fluctuations, the existing programs, the time offsets between intersections at the beginning of the "green light period" inside the program, and the actual measurements realized in the major interest areas on this artery have been also taken into consideration.

1. Deffining of flows data

The flow represents the road section through which a vehicle travels, this being limited between different "Stop Points" (the horizontal red lines from intersections). In the example below two more flows are presented: from the top to the bottom (the yellow line on the map) for a direction (called flow down) and from the bottom to the top (the blue line in the image) for the other direction (called flow up).

The flow down has two "Stop Points" and on the the other flow, the flow up, there is only one "Stop Point." As each and every segment before the "Stop Point" must be identified, the start point of the case study (the green wave) has been indicated by a red dotted line.

For adding a new flow, right click on one of the flows (flow up – the direction going upwards) and select "Add flow entry." On the lower left side of the program (the controllers'area) there will appear frames where you can complete the following:

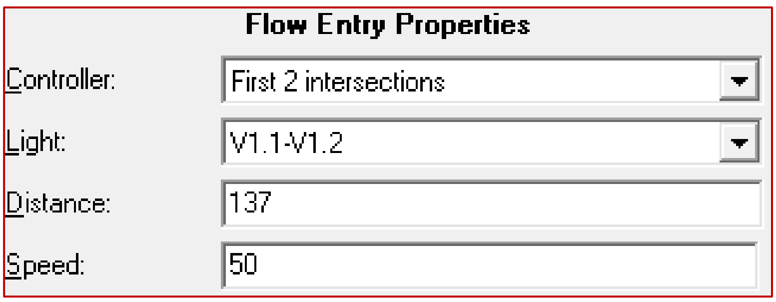


Controller: this frame is used for selecting the controller that monitorizes the semaphore from the stop point.

Light: this frame is used for selecting the semaphore (semaphores) of the desired flow monitorized by this controller.

Distance: the distance in meters from the beginning of the section.

Speed: the medium speed is introduced on this road section.



If we analyze the green wave for only one flow then, only one of the flows will be introduced. If we analyze a green wave on two flows, then the afferent data for both flows must be introduced. In addition, at the end of the segment chosen for the accomplishment of the green wave, a buffer road segment must be added, having the same length as the one at the beginning of the green wave. In order to modify the data of the flow, right click on the respective flow and the data can be modified from the frames appearing in the lower left part of the program.

Options:In the tab "Options" the following setting can be modified:

Distance scale: in the time distance diagram, the axis Y represents a number of meters on the road. The predefined value is that of 10 m but can be modified from this tab.
Diagram time: in the diagram produced by the program, the axis Y represents the time expressed in seconds, each step being one second long. With this setting we can change the total time, which is presented inside the diagram.

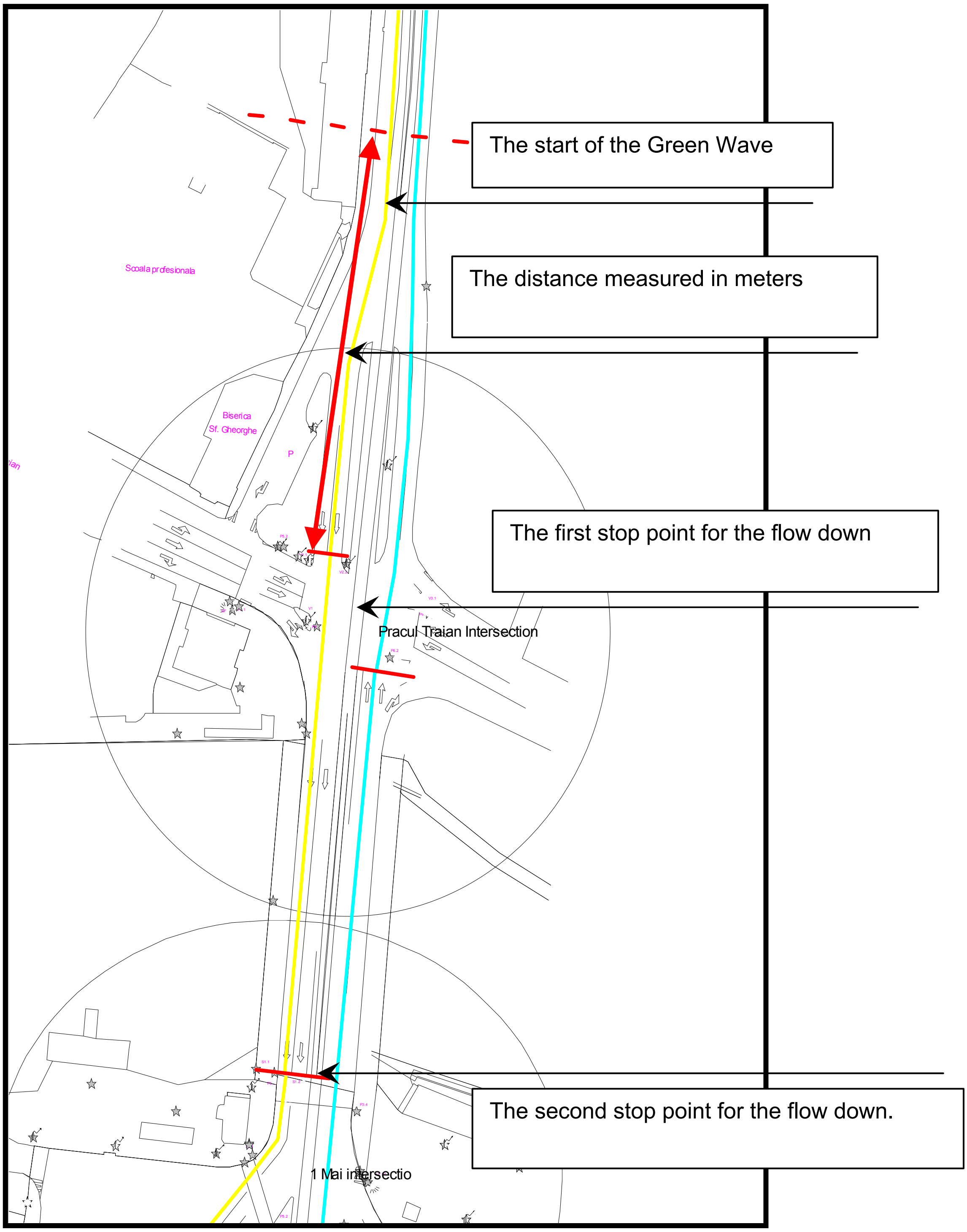


Fig. 1 –General scheme of two intersections green wave

2. THE TIME DISTANCE DIAGRAM

This type of diagram produced by the program is the last method that can be used for evaluating a Green Wave and its improvement. The program GWTOOL allows the visualization of the green wave on one of the flows or on both of them. For representing the diagram click on the desired flow and the diagram will be generated (in the case that the option “lock” from the menu “View menu” has not been selected).

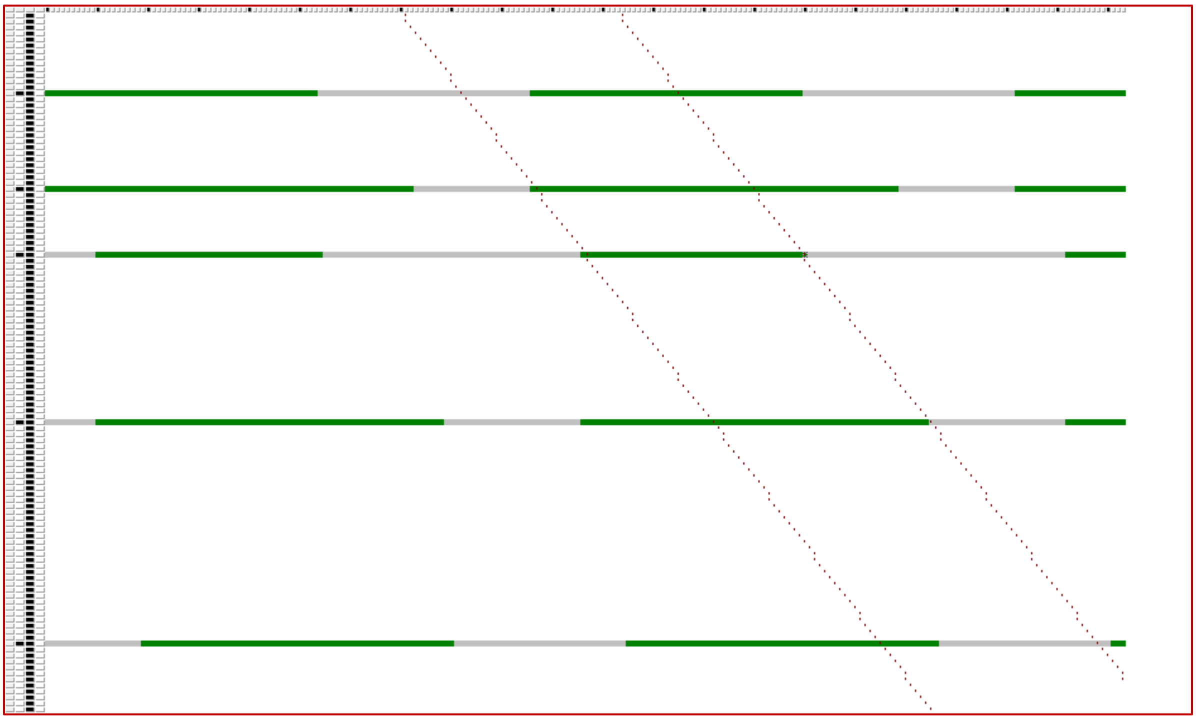
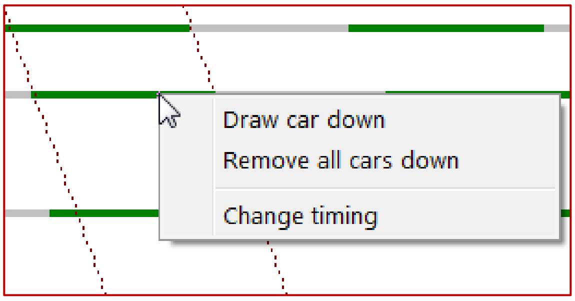
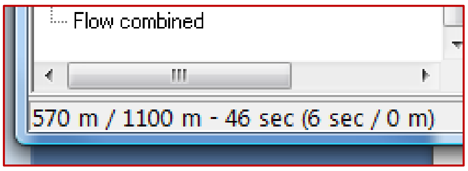


Fig. 2 - The time distance diagram

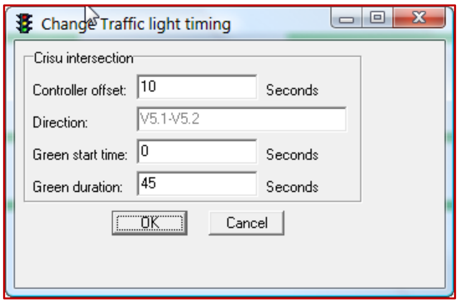
The Axis X represents the time expressed in seconds. In the upper part of the diagram there are markings for each 10 seconds span.
The axis Y represents the distance on the selected road segment. Each 10 seconds time segment has an identical correspondent on the axis X expressed in 10 meters sections. On the left side of the image above (the grey dotted line) each stop point is represented, and on the sketch the green color is presented in conformity with the moments (the green light moments) and with the time lags of the controllers, which monitorize these semaphores.
For an easier visualization of the vehicle path on the created itinerary, the program offers the possibility to indicate the route a vehicle will follow, taking into consideration the distance of the road segment and the medium speed that has been introduced for that segment.
First we click on the spot from the diagram where the car should pass by and then, right clicking, use the option “Draw car down”; therefore a diagonal line will appear on the diagram, this representing the route/itinerary of that car through the succesive intersections.



The maximum number of cars that can be represented is 5. Usually these lines will be drawn for the green light period inside the chosen road segment. By selecting the option “remove all cars down” you’ll erase all the lines inside the diagram.



Click on one cell of the diagram and you’ll notice that in the bottom menu bar there will be information regarding that point in the diagram. The value (in time and length, seconds and meters) between the latest selected point and the one before that will be displyed in brackets. This option is extremely important and useful for correcting the time lags of the different controllers inside the diagram.



If one click on a line inside the diagram which represents a stop point you are offered the possibility to modify the already inserted data for that stop point (intersection). A window will appear on the screen allowing the change of the controllers’time lag or the green light period afferent to the stop point selected inside the diagram. Any modification related to the time lag of the controller will influence both flows.

If the times of a certain flow change, the possible discrepancies, which appear in the same section, must be also modified.

If the combination of both flows has been selected on the left side (the controllers’area) then the diagram will present an image with both flows:

In this situation two cars can be designated for each flow in order to evaluate the Green Wave from both directions.

In order to find the best green period succession along the coordinated itinerary it is necessary to build a space-time diagram, as the one in the figure 2, which presents the theoretical itinerary with four intersections, three of them being semaphorized. The relative implementation of each signal is specified by the offset, which represents the difference between a refference time considered the origin of the space-time diagram, and the beginning of the first complete green light.

The two pairs of drawn parallel lines represent the constant speed or the paths of the first and the last vehicle of the group, in the direction in which the intersection clears, without stop. The time difference between the parallel paths for each direction of the flow is known as “complete flow lane”.

If we divide the complete lane to the average of time intervals between the vehicles, we obtain the number of vehicles that form the continual vehicle group. The width of the complete lane, measured in seconds, can be adjusted by translating of the signal in horizontal direction. A “balanced” model refers to the case when the complete both way lanes are equal. Such a model is not always the best. For the moment, the preferential model may be suitable in the morning or in the afternoon, during the rush hours, on the streets with unbalanced directional flows (similar). The solution for a coordinated signal may be the graphic, analytic, or computerized resolution, using some simple equations. For example, the time spent by a vehicle for travelling the distance between the intersections with a constant speed is equal with the proportion between the space and speed (x/v).

Therefore, following the equation, the offset must be used, in order to make the difference between the state of the signal in each moment t=T in relation with the reference point t=0: Time on cycle = {t - offset} module c.
The duration of the green, yellow or red light signal being known, we can mark the position in any moment t = T. The role of this offset is of assuring delays as small as possible for the vehicles inside the group. Unfortunately, the ideal solution cannot always be adopted because of some factors such as:

- The distances between the intersections;
- The different number of lanes on each flow;
- The movements in and out of the main flow etc.

  Under these conditions, the distance between the intersections can be expressed by the following equation:

$$D = \frac{v \cdot C}{2} \tag{1}$$

The different speeds imposed to the groups for both travel directions allow the following equation for the distance between the intersections:

$$D = \frac{v_1 \cdot v_2}{v_1 + v_2} \cdot C \tag{2}$$

The above written equations show a dependency between the three factors: speed, distance and the cycle length. As distance is a constant proportion, only the other two can be modified for obtaining an optimal solution, which means a speed between certain limits and a cycle length that correspondes to the traffic request with minimal delays for all the participants.
In the situation presented in figure 3 we can notice that, if a vehicle (B) from the group starts rolling with a constant speed equal with the recommended speed, it will cross all the intersections. If a vehicle (A) starts with a speed considerably higher than the constant indicated speed, it will cross on time and more favorably the intersection (2) and (3) in which there are green light signals, but in intersection (4) it will “catch” the yellow light or red light signal.
For vehicle (C) that will travel with a speed inferior to that recommended, we can notice that it will cross continuously only through the first two intersections arriving at intersection (3) at yellow light signal, and it will have to wait until the appeareance of the next green light signal.
In an ideal situation, we will obtain a “green wave” characterized by a continuous lane having the width *Uv*.

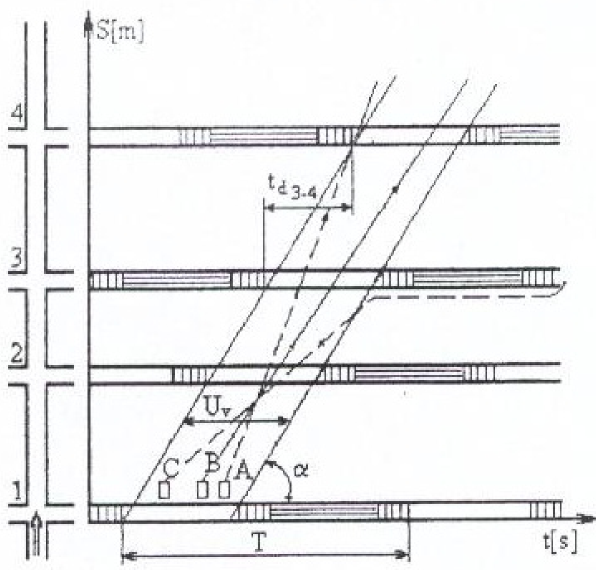


Fig. 3 – Correlation of the intersections in "green wave"

As a matter of fact, the possibility of keeping constant the width of the lane is conditioned, first of all by the variation of the circulation flow which moves on direction of the wave as well as by the opposite flows inside each intersection.

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[***] User Manual GWTOOL